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ELECTRON-ATOM AND ELECTRON-MOLECULE CROSS SECTIONS APPLICABLE T--ETC(U).

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FINAL REPORT.

1 Jul 74 - 31 Jun 76

Contract N00014-76-C-0077

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An Extension of

Contract N00014-67A0097-0015

Covering period 7/1/70 through 6/30/76

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Title: Electron-Atom and Electron-Molecule Cross
Sections Applicable to Atmospheric and
Ionospheric Behavior.

Principal Investigator:

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Vernon W. Hughes
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Vernon W. Hughes
Donner Professor of Physics

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Final Report on Navy Contracts N00014-67A0097-0015 and
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The research accomplished under ONR contracts N00014-67A0097-0015 and N00014-76-C-0077 for the period July 1, 1970 through June 30, 1976 is summarized in this report with reference to our publications.

Work on the production of spin polarized electrons (first begun under an earlier NONR #609(53) contract) continued during this period. Photoionization of polarized atoms in an atomic beam was one method studied (Ref. 2). A high intensity pulsed source of polarized electrons based on this method and using Lithium was developed and installed as a gun on the SLAC 20 GeV linear electron accelerator (Ref. 4,6, Abstract No. 3,5-7). This source has been used by now in several basic high experiments, which were the first to use high energy polarized electrons. A second method studied was the Fano-effect, or spin-orbit interaction in the continuum for heavy alkali atoms. (Ref. 1) A source of low energy polarized electrons using the Fano effect in Cs was developed (Abstract No. 1, Publ. Submittal No. 1) with the aim of studying polarization effects in the scattering of polarized electrons from polarized hydrogen. Toward this goal a general purpose crossed beams apparatus for scattering electrons from atomic or molecular beams was constructed. The apparatus features Hg-pumped all stainless steel bakeable chambers capable of reaching pressures below 10^{-9} torr. A polarized hydrogen source was developed using state selection of a thermally dissociated beam in a six pole magnet.

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Considerable experimentation in design of both the polarized electron and polarized hydrogen sources was required before suitable intensities could be obtained to study the desired e-H elastic scattering asymmetry. Elastic scattering of polarized electrons from polarized hydrogen was first observed in Spring 1976 (Abstract No. 4) and subsequently preliminary asymmetries were reported at several energies (Abstract No. 8). Since expiration of this contract, work has continued and the asymmetry in the ionization of atomic hydrogen by electron impact has been measured at energies from 15 to 200 eV. (Ref. 7) Additional measurements of elastic scattering asymmetries are currently in progress. These measurements constitute the first experiment in which polarized electrons are scattered from polarized atoms, and indeed our experiment studies the simplest, most basic case of scattering from hydrogen.

Our development of polarized electron sources has involved the study of electron spin effects in atomic photoionization. Practical sources of polarized electrons have made possible the study of cross sections for spin dependent electron-atom scattering and hence a clean separation of exchange from direct interactions. Such information, which we now have for electron-hydrogen scattering, and are now able to obtain for other atoms (and molecules), is of great value for developing the correct approximations for scattering calculations. Improved approximations in scattering theory are very relevant to the understanding of atmospheric phenomena, lasers, and plasmas.

NAVY

N00014-67-A-0097-0015 and N00014-76-C-0077

July 1, 1970 - June 30, 1976

Publication List

Publications

1. "Measurement of the Spin-Orbit Perturbation in the P-state Continuum of Heavy Alkali Atoms: K, Rb and Cs," G. Baum, M.S. Lubell and W. Raith, Phys. Rev. A 5, 1073-1087 (1972).
2. "Polarized Electrons from Photoionization of Polarized Alkali Atoms," V.W. Hughes, R.L. Long, Jr., M.S. Lubell, M. Posner, and W. Raith, Phys. Rev. A 5, 195-222 (1972).
3. "The Third International Conference on Atomic Physics," V.W. Hughes, Comments on Atomic and Molecular Physics, Vol. IV, No. 2, pp. 35-41 (1973).
4. "Polarized Electron Source for the Stanford Linear Accelerator," M.J. Alguard, R.D. Ehrlich, V.W. Hughes, J. Ladish, M.S. Lubell, W. Lysenko, K.P. Schueler, G. Baum, and W. Raith, Proceedings of the IXth International Conf. on High Energy Accelerators, Stanford Linear Accelerator Center, Stanford, Calif. May 2-7, 1974, pp. 309-313.
5. "Polarized Electrons," M.S. Lubell, in Atomic Physics 5, edited by R. Marrus, M. Prior, and H. Shugart (Plenum, New York, 1977), pp. 325-373.
6. "Depolarization Effects in Pulsed Photoionization of State-Selected Lithium," M.J. Alguard, J.E. Clendenin, P.S. Cooper, R.D. Ehrlich, V.W. Hughes, M.S. Lubell, G. Baum and K.P. Schuler, Phys. Rev. A 16, 209-212 (1977).
7. "Measurement of Spin-Exchange Effects in Electron-Hydrogen Collision: Impact Ionization," M.J. Alguard, V.W. Hughes, M.S. Lubell and P.F. Wainwright, Phys. Rev. Lett. 39, 334-338 (1977).

Abstracts

1. "A Polarized Electron Beam for a Low-Energy Scattering Experiment, Produced by Fano Effect in Cesium," G. Baum, M.S. Lubell and W. Raith, Bull. Am. Phys. Soc. 16, 586 (1971).
2. "Spin Effects in Alkali Photoionization," W. Raith, Bull. Am. Phys. Soc. 16, 487 (1971).
3. "A High Intensity Pulsed Source of Polarized Electrons," M.J. Alguard, R.D. Ehrlich, V.W. Hughes, J.S. Ladish, M.S. Lubell, K.P. Schueler, G. Baum and W. Raith, Fourth International Conf. on Atomic Physics, ed. by J. Kowalski and H.G. Weber, Abstracts of Contributed Papers, Heidelberg, Germany, pp. 373-376.
4. "Low-Energy Elastic Scattering of Polarized Electrons by Polarized Hydrogen Atoms," P.F. Wainwright, M.J. Alguard, G. Baum, V.W. Hughes, J.S. Ladish, M.S. Lubell and W. Raith, Bull. Am. Phys. Soc. 21, 573 (1976).
5. "Resonant Two-Photon Effects in Photoionization of State-Selected ^6Li ," M.J. Alguard, J.E. Clendenin, V.W. Hughes, M.S. Lubell, K.P. Schuler, R.H. Miller, G. Baum, and W. Raith, Bull. Am. Phys. Soc. 21, 35 (1976).
6. "New Developments in PEGGY, the SLAC Polarized Electron Source," M.J. Alguard, J.E. Clendenin, V.W. Hughes, M.S. Lubell, K.P. Schuler, R.H. Miller, G. Baum, and W. Raith, Bull. Am. Phys. Soc. 21, 35 (1976).
7. "Resonant Two-Photon Ionization Effects in the SLAC Polarized Electron Source," J.E. Clendenin, M.J. Alguard, P. S. Cooper, R.D. Ehrlich, V.W. Hughes, M.S. Lubell, G. Baum, K.P. Schuler, W. Raith, and R.H. Miller, Abstracts, Fifth International Conf. on Atomic Physics, ed. R. Marrus, M.H. Prior and H.A. Shugart (Berkeley, Calif., 1976), pp. 431-433.
8. "Low-Energy Elastic Scattering of Polarized Electrons by Polarized Hydrogen Atoms," M.J. Alguard, V.W. Hughes, M.S. Lubell and P.F. Wainwright, Submitted to the ICPEAC X, July, 1977, Paris, France.

Submitted for Publication

1. "The Application of a DC Fano Effect Polarized Electron Source to Low-Energy Electron-Atom Scattering," P.F. Wainwright, M.J. Alguard, G. Baum, and M.S. Lubell, to be submitted to Phys. Review A.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Polarized electrons have been produced by photoionization of polarized alkali atoms by unpolarized light and also by photoioniza- tion of unpolarized alkali atoms by polarized light (Fano effect). Practical sources based on these approaches have been made. The first experiment to study the low energy scattering of polarized electrons by polarized atoms (electron-hydrogen) has been done with the Fano effect source. The other source provides polarized electrons.		

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20. ABSTRACT (cont'd)

for acceleration to high energies at SLAC and has been used in basic pioneering experiments in elementary particle physics. The atomic scattering studies with polarized electrons improve our understanding of the approximations in theoretical calculations of electron-atom scattering cross sections.